Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of:) MB Docket No 99-325.

NRSC-5 / IBOC Broadcasting)

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To: The Commission

COMMENTS OF Gregory J. Buchwald

I Gregory J. Buchwald, as technical representative for WRPQ-AM, pursuant to the Notice of Proposed Rulemaking, MB Docket No. 99-325, hereby submits its comments on the Commission's request for comment on the matter of NRSC-5 and Digital Audio Broadcasting within the AM and FM broadcast bands.

Executive Summary

This filing of Comments will present information pertaining to the unacceptability of NRSC-5 on several levels as well as the level of interference generated by the IBOC-AM system. While much has been said about the qualities of the system, an in-depth analysis of the interference caused to other broadcasters, particularly on the second adjacent channel, and the impact on the current allocations table must be investigated and discussed. During 2004, Comments and Reply Comments were filed regarding the acceptance of the Ibiquity IBOC-AM transmission system, also known as HD-Radio. This paper will present information on the following:

1. The NRSC-5 bandwidth limitation proposals are too restrictive for broadcasters.

2. The IBOC-AM system, in its present form, creates unacceptable, and illegal levels of interference to second adjacent channel stations,

3. Interference generated to the second adjacent channel stations is done so to avoid increasing analog noise to the IBOC-converted stations own audience; the noise penalty is shifted from the licensed station performing the conversion to IBOC to both of the second adjacent stations +/-20kHz from the converted stations carrier frequency,

4. A solution exists which dramatically reduces the second adjacent channel interference at the expense of increased analog noise on the licensed IBOC channel,

5. Techniques derived to indicate compliance with occupied bandwidth / out-of-band power emissions of analog systems by the NRSC in the late-1980's are not sufficient for constant power, multi-carrier digital systems, and,

6. Regulations developed to control the transmission of <u>Unintentional Radiation</u> should not be directly applied to the control of broadcast energy due to <u>Intentional Radiation</u>.

7. IBOC-AM is a hindrance to the most basic form of information dissemination, which is increasingly important to homeland security in this post-9/11 (2001) environment. It is also extremely important during times of severe weather, such as tornado warnings, hurricane forecasts, and other natural events – particularly in rural areas; areas in which the

coverage of AM stations will suffer the most due to IBOC-AM transmissions on first and second adjacent channels.

8. IBOC-AM will never allow AM broadcasters to enjoy quality of service approaching that of their FM counterparts, and

9. If IBOC-AM is allowed to continue daytime service and initiate nighttime service, some form mitigation and compensation to damaged stations must be anticipated and put into place.

10. A reallocation plan does exist which would be relatively easy to implement and which would allow the AM broadcasters to “leap-frog” over these problems while maintaining the critical link to all potential listeners of AM stations, whether it be for farm reports on a daily basis or in the case of a natural or manmade emergency / disaster.

The terms <u>Intentional Radiation / Radiator</u> and <u>Unintentional Radiation / Radiator</u> will be introduced and discussed. These terms are common in FCC discussions; however, they need to be put into perspective with respect to AM broadcast rules, and, in particular, Rule 73.44.

In addition, it will be shown that limiting the radiation of power beyond the +/- 10kHz allocations present in the AM band to the level for which the current rules were developed during daytime operation will also solve the nighttime interference problems associated with, and stopping the current transmission of the IBOC signal at night.

Audio Limitations

Simply put, broadcasters should not be required to reduce their audio bandwidth below the current 10kHz limitation. When NRSC-1 took affect, there was a clear reduction in interference; particularly from second adjacent channels. I was a NRSC voting member at the time and must admit it was a difficult choice to make. Ultimately, the reduction of interference was borne out and the 10kHz limitation, proposed by Robert Orban, a leading authority in psychoacoustics and audio processing, was good for AM broadcasting in general. This statement can only be made based on the fact that a reduction of interference, enjoyed by all broadcasters took place. In the case of the current discussions, whether it be a 5, 6 or 8kHz limitation, no improvement will be realized to the vast majority of the public as well as the broadcasters themselves unless the RF emissions mask is similarly reduced. That is to say that if a 5kHz limitation is employed, the mask must also be reduced such that the –25dBc point coincides with 5kHz removed from carrier and the –35dB point coincides with +/-10kHz. As the author of the current RF emissions mask, adopted in basis by the FCC and now Rule 73.44, my authority on this matter is a matter of public record.

In the case we are considering now, the IBOC broadcaster will gain to some extent, but those that choose not to convert, whether it be due to low power operation (<5kW), interference from other IBOC AM stations, or economic / market constraints, will not gain any benefit from a reduction of audio bandwidth without a reduction of allowable occupied bandwidth from 20k0 to 10k0 or at least 12k0. Furthermore, listening tests with 6kHz and 4.5kHz NRSC-1 roll-off rate cards in an Optimod 9100B2 processor indicate a reduced perception of quality over 10kHz audio limitations on several production receivers. A short listening test with a major broadcaster in Chicago within the past month bore out the same results. While some of this perceived reduction of audio quality can be minimized through the use of higher levels of pre-emphasis, it is never as good as with the 10kHz filter. Similar tests have been conducted with the digital Optimod 9200.

Having worked with CRL on the MBL-100 (now the AmigoTalk) processor for use on Radio Free Europe / Radio Liberty in a 4.5kHz version and AM News /Talk formats in a 7.5kHz version, I can state that one can achieve an increase in loudness on narrow band radios. But the use of these filters should be at the discretion of the broadcaster; not a further restriction imposed by FCC rule with no valid engineering basis in interference reduction.

Background on the Discussion of IBOC-AM / FCC Rules Compliance

The advent of IBOC digital radio transmissions, particularly within the AM band, has raised the issue of increased interference due to the digital sidebands. A simple reading of the current FCC rules implies that the addition of the primary sidebands[3] (located between 10 and 15kHz removed from the main AM carrier in the hybrid system) and the resulting increased spectral energy, are within the mask, and therefore only generate allowable interference to other stations. The current NRSC compliance rules pertaining to occupied bandwidth for AM transmissions in the 540 – 1700kHz band were written to allow a convenient way to measure the level of interference and provide the means to maintain it at an acceptable level. Power is very difficult to measure when it occurs on a sporadic basis; it is the integration of energy over a fixed period of time. The rules were written in such a manner that what was effectively measured was <u>peak voltage</u> recovered at the input of a sensing device, with a fixed input impedance, given a predictable bandwidth and filtering system prior to recording of the peak voltage level. I have first hand knowledge of these rules I authored the proposal from which they were written in 1987 when I was an active member of the NRSC AM Improvement Committee. At that time, the committee was concerned with the spurious generation of harmonic and intermodulation energy outside of the +/- 10kHz passband limits that were to be imposed. Considerable testing of transmitters was undertaken to determine whether the proposed rules were compatible with existing broadcast equipment, which they were, and whether or not the occupied bandwidth measurements could be undertaken by broadcast facilities on an annual basis the NRSC mask measurements we must all perform each year. The sole purpose of the mask was to limit the generation of out-of-band radiation (unintentional radiation) caused by one of two potential sources:

1) Spurious radiation created by unfiltered clipping of the final audio product which would cause non-linear products to appear in the modulated audio spectrum, and
2) Excessive out-of-band components caused by transmitter malfunctions such as excessive harmed audio distortion, large amounts of Incidental Phase Modulation (IPM), and other factors associated with faults of the transmission system. It also insured that broadcast stations incorporated audio filtering within their audio processing chain that met the NRSC requirements.

With the advent of digital broadcasting, it has been assumed that one must only measure the occupied spectrum as we always have done in the past, and meet the mask. In fact, that is the current interpretation by those that currently broadcast the IBOC-AM system. While a perfectly good argument can be made for this interpretation, the level of first and second adjacent channel noise associated with IBOC broadcasts has caused many to consider the worthiness of such arguments. The remaining portion of this filing will discuss how that frame of thinking may be incorrect when one considers the addition of the multi-carrier, digital energy.

<u>The Nature of Interference Measurement and Practical Verification Techniques</u>

The data I present herein has been determined, calculated, and reduced to practice based on information obtained from the Ibiquity IBOC-AM specification dated November, 2001 as available on the web, the FCC rules as published and specifically 73.44, published reference materials, and data obtained through field collection on installed IBOC-AM facilities.

The mask taken from 73.44 was not simply taken from random practice. It has its roots in good engineering practice that goes back over ¾ of a century. In 1987 when we undertook the revision of the occupied bandwidth rules (NRSC AM Improvement Committee), those basic engineering practices were re-visited, re-evaluated, and, ultimately, re-confirmed. Consider the co-channel protection ratios required for construction of broadcast facilities. Co-channel contours of 25uV against the 500uV contour of the protected station must be maintained. The .5/.025mV/m contour represents a ratio of -26dB. The second adjacent channel allocation required, at the time of the NRSC rules study period, that the 2mV/m contour of the desired station can not cross the protected 25mV/m contour this is a ratio of 21.9dB. As a result of the study done by the NRSC, this was increased such that the 5mV/m contours must not overlap. Although this could be interpreted as a 0dB ratio, one must keep in mind that we will discuss the interference in terms of co-channel equivalence. A common theme of a value approaching -25dB can be found in both of these numbers. In fact, since both are referenced to carrier level, but the interference level to the second adjacent is actually based upon modulation terms, which, at 100% modulation are -6dBc, the actual second adjacent protection against modulation products is 27.9dB. The key here is not the actual calculation; however, it is the fact that the level of unintentional radiation is based on a factor derived from the reduction required to meet the allowable energy on the second adjacent channel if the out-of-band transmitted energy were intentional in nature. Let us consider a 50kW broadcast station: The total allowable radiation on the second adjacent would be about 200 watts (199 calculated). For a 1kW station, this value drops to 4 watts and for a 250 watt station; it is a mere 0.5watts. Keep in mind that the lower limit on radiation does not aid lower power stations, the {-73 +43log power} rule only comes into effect well beyond the close-in out-of band radiation limits. Of course, when the upper and lower sideband out-of-band limits are considered, these power calculations go up by a factor of 2.

Let us now consider an analog broadcast one for which the current rules were written. The broadcast power outside of the assigned channel tends to be fleeting in nature. Furthermore, it also tends to be harmonic in nature; generated by harmonic distortion of the audio components and / or incidental phase modulation from the same components. In fact, with the 10kHz low-pass filter requirement of NRSC, the only band of audio products which could produce energy in the 10 - 20kHz (removed from carrier) spectral locations are second harmonics of audio energy from 5 - 10kHz fundamental, third harmonics from 3.3kHz to 6.6kHz, and inter-modulation components which tend to be lower in value at these higher modulation frequencies (due to the fact that the energy at the higher frequencies tends to be reduced from a peak at 200 - 400Hz, even with processing, by 6 - 10dB or more.) Since few terms, and often times only 1 or 2 terms, are generated across this spectrum at any given instant in time, the power in these unwanted sidebands can be determined by use of a common power spectral density (PSD) measurement. It can also be measured on a static basis by modulating the transmitter with a steady state tone, or combination of tones. When doing so, the real power in a portion of the band, for example 10 - 20 kHz removed from carrier, can be determined by measuring the voltage generated and delivered to a load. In the case of monophonic AM transmission (envelope only), a 5% second harmonic component will generate a sideband term at -32dBc (26dB below the fundamental tone). If the tone is at 6kHz, this term appears at 12kHz. Prior to AM stereo and the introduction of solid state transmitters, there often existed as much incidental phase modulation present as there was envelope modulation, particularly at the higher frequencies. If sufficient IPM was present, or if the antenna coupling network limited the energy available in one sideband at the harmonic term, the distortion term may rise to as much as -26dBc. The latter is quite common with narrow-band directional array systems; especially when envelope feedback is present within the transmitter. While the envelope distortion term will read the same, the sideband power delivered, in the form of interference, has risen on one sideband. It is clear from this data why proof-of-performance limits of old were chosen with the distortion limits as they were. The distortion terms would create a power level under steady state conditions that would create the maximum allowable power outside of the assigned channel. In the case of programming, the power generated is generally nowhere near as great as that from a steady-state tone, but the peak voltage that to which the receiver being interfered with is the same. Therefore, the perceived interference is of the same consequence. AM stereo broadcasting was not much different; it could be argued that additional compatibility sidebands were generated, but the power in each higher order term contributed little to the out-of-band radiation total power as compared to the first harmonic distortion (second order) term.

Digital broadcasting, particularly an OFDM system, is quite different. First, the out-of-band energy is created by a number of closely-spaced carriers. In the case of IBOC-AM, there are 24 carriers that occupy each sideband starting from 10kHz up to 15kHz removed from the carrier frequency. When out-of-band power is calculated, it must be done so by either filtering the channel and finding the total power in the 10 - 20kHz region removed from carrier, or it must be calculated. The second approach is actually easier to perform. Consider a single carrier at -26dBc. The power in a single OFDM carrier is 1/400th of the carrier power level for a 50kW station, it is 125 watts. As additional carriers are added, the power across the spectral range form 10 to 15kHz removed from the assigned carrier frequency is increased, while the PSD, as measured in a 300Hz bandwidth as suggested by the NRSC / 73.44 rules, will remain the same. This is common problem for satellite communications one must consider the power reduction from a transponder on a per-carrier basis as additional carriers are added. To simplify the calculation, one can assume the reduction to simply be 10log1/24 = 13.8dB, which is about 2 -3 dB less energy than that which has been published elsewhere; I prefer to err on the conservative side with this calculation (allowing more power to be generated for IBOC transmissions on the primary sidebands). The reason for this slight reduction of the PSD below the 13.8dB is caused by the fact that each of the carriers in an OFDM system is modulated, thus causing a small spreading factor, with associated reduction of PSD to occur. IN addition, the probability that each term will peak simultaneously approaches zero, thus causing the PSD to also appear slightly lower than predicted by the simple means presented above. Although the published spec indicates that the primary IBOC sidebands must be at least -25dBc (FCC 73.44), the IBOC spec shows -26dBc for QPSK modulation and -30dBc for an overall number. Measurements I have taken fall in the middle; about -28dBc, which is the number I will utilize for the second adjacent power calculation. The numeric power multiplier for -28dBc is .00158x. The power for a discrete carrier at -28dBc is 79.25 watts for a 50kW station. To find the total power across the range from +/- 10kHz to - +/-15kHz, we must increase number by the 13.8dB factor determined above. Therefore, the actual power radiated per primary sideband for a 50kW station is -14.2dBc, or 1900 watts. This number is key; we will revisit it shortly. This indicates that an IBOC station, running 50kW of carrier power, is transmitting at least 3800 watts of digital power in the primary sidebands. Since the secondary sidebands are about 10dB below the level of the primary sidebands, they contribute 1/10 the power of the primary sidebands and little to the actual overall power budget for the IBOC transmission. Also note that if the injection is raised to the -25dBc limit, the primary sidebands now convey 5625 watts of power. If the overall radiated power of the digital and analog signals remain the same, the analog carrier must be reduced to 46,200 watts in the case of a -28dBc injection level and 44,375 watts in the case of a -25dBc injection level. In the worse of the two cases, this results in a reduction of equivalent analog power of -0.51dB; hardly noticeable to the analog listener. But the same 5625 watts, equally split between two second adjacent stations is another story it is almost like bringing a 2500 watts station up co-channel to the operator of the second adjacent channel stations on both sides!

Reconsider the rules, and in particular, 73.44. The NRSC measurement technique is described as using a spectrum analyzer, sweeping the spectrum with a 300Hz bandwidth, for a period of 15 minutes. The filter bandwidth is chosen such that the rise time is fast enough to catch the peak voltage present at the input of the analyzer, and the integration time is chosen such that enough peaks are collected as to indicate the peak voltage across the channel; if a single sweep were utilized, one might catch a single peak, or possibly no peaks at all. In fact, the FCC allows the filter bandwidth to be increased above 11.5kHz removed from the carrier in order to accept short duration peaks that are not repetitive. If one measures an IBOC signal, a single sweep will capture nearly the same spectrum as a 15 minute peak hold. The reason is that the power is there constantly, it is at all locations, regardless of filter position (instantaneous frequency and bandwidth of the swept frequency analyzer input), and it is actually a Power Spectral Density (PSD) measurement. But PSD is not the number we need to know; total power across the channel is the basis for interference when considering the adjacent and second adjacent channels. If one does a simple calculation to take PSD in 300Hz bandwidth and find the total power across 5kHz (from 10kHz to 15kHz removed from carrier), the resultant is 10log(5000/300) = 12.2dB. This is slightly lower than the 13.8dB assumed from the number of carriers, but this is to be expected since the OFDM carriers are interleaved and randomly modulated.

It is also important to note that the FCC does specify that in the region beyond 10kHz removed from the carrier of the station to be measured, the bandwidth of the spectrum analyzer utilized to measure the out-of-band radiation can be increased.[1] Taking this towards a limit on bandwidth for the IBOC system, the spectrum analyzer IF bandwidth could be increased to 3kHz or even 5kHz. Now, if the secondary sidebands are temporarily switched off, the spectrum analyzer will measure the energy present as a sum of all of the primary OFDM sidebands on one side of the carrier. When this is done, a storage time of even a minute or so will indicate a level of energy significantly higher than the –28dBc measured on a per-carrier basis. That is due to the fact that all of the energy due to one set of primary OFDM carriers are now additive within the passband of the spectrum analyzer IF. The resultant energy detected will increase nearly to the 13.8dB level calculated. If this interpretation of the FCC rules on compliance is utilized, the energy in the primary sidebands of the IBOC system automatically does not meet the criteria required for out-of-band energy specified in 73.44.

When it comes to interference calculation, one must consider the intent of the rules. It is clear that the basis for the -25dBc point in the spectral mask is to control unintentional radiation on the first and second adjacent channels to the levels that would be allowed assuming intentional radiation on these channels. The calculations based on co-channel to second adjacent interference, as well as the radiated power due to audio distortion and IPM both back up this value within a dB or so. When one was broadcasting analog AM, whether monophonic or stereophonic, the intentional bandwidth was +/-10kHz from carrier all else is unintentional radiation. With IBOC, the so-called Primary" sidebands, located +/-10 and +/-15kHz from carrier are intentional radiation; the system does not operate without them! They are not generated as a byproduct of higher order distortion or other undesirable effect; rather, they are generated as fundamental terms that must be transmitted and received for the system to operate. One can call this semantics, but an argument can be made that a broadcast facility is not licensed to transmit Intentional radiation beyond the +/-10kHz allocation they own. Unintentional radiation must, furthermore, be limited to the power levels discussed earlier in this paper. At a minimum, if intentional radiation is allowed to encroach upon the licensees of other adjacent or second adjacent broadcast facilities, as is the case in IBOC-AM, they should be limited to levels of total allowable power, not PSD. The data presented within this paper on these calculated values are based on sound engineering practices.

What does this all mean for IBOC? First, whether one wants to accept the fact that the radiation into the first and second adjacent channels is intentional or unintentional, the spirit in which the rules were written (73.44) must be observed. While the description of one method to measure the out-of-band radiation reads as a PSD measurement, it must be remembered that that method was created for ease of yearly compliance using readily available equipment. It was intended for the measurement of sporadic signals, not continuous signals from multiple carriers as is the case with IBOC, and relies on integration over time to show that fleeting peaks of energy do not create a situation equivalent to a given amount of radiated power. To retain the same level of second adjacent channel interference potential from an IBOC-AM transmission, the energy measured beyond 10kHz from carrier must be reduced such that the PSD in the affected channel is limited to that which was calculated above. In the instance of a 50kW broadcast facility, the acceptable power level in that band is 200 watts. To reach this point, the measured occupied bandwidth, using the PSD method (NRSC compliance), must be the mask limit, -25dBc, plus the effective carrier drop due to distribution of energy across the 24 sub carriers, (-13.8dB). Thus, to insure that interference limits are not increased over the current day analog situation limits, the level of energy radiated from +/-10 to +/- 15kHz must not exceed -38.8dBc. This is nearly 11dB lower than that currently used in IBOC transmissions. At these power levels for the transmission of the digital primary sideband information, the interference to a second adjacent will be identical to that caused by an analog station just meeting the NRSC mask limits. In practice, most AM stations are at least 10 - 15dB better than this, so reducing the IBOC system levels to the -39dB (-38.8dBc) value will still result in a 10 -15 dB <u>increase</u> in effective interference to second adjacent stations. While it can be argued that the energy generated to the second adjacent channel receiver will be in the upper 5kHz of the channel, receivers do not have brick wall filters. Even if the receiver is down 10dB at 5kHz, it will still receive interference equivalent to 10 to 20dB greater than that experienced today. More importantly, the licensed channel is a financial asset. Each broadcast facility is entitled to protection of the licensed channel, which is the entire 20kHz they are assigned. Just as in property rights, a second adjacent broadcast facility is not entitled to generate interference to stations beyond the channel they are assigned to the limits discussed above, whether it is on the basis of intentional or non-intentional radiation.

On-Air Validation of the Increased Interference Levels Generated by IBOC-AM

Actual measurements of an on-the-air IBOC transmission confirm the theoretical data contained within this text. Measurements have been conducted on WTMJ; licensed to Milwaukee with an operating power of 50kW daytime. IBOC operation is not allowed at night, so no measurements have been made at night. Having worked with the late Will Koeller on the construction of the WTMJ-AM transmission site in Union Grove about a decade ago, I am familiar with the radiation pattern of the station. I have included plots of WTMJ, indicating their 0.5mV contour, whish is tangent to the border of Iowa, Wisconsin, and Illinois. I also include a plot of the 0.5mV contour of WMT in Cedar Rapids, IA operating on 600kHz. The reason I chose these stations is many-fold: 1) It is close to my residence and therefore easy to acquire data, 2) They are both old, established stations with WMT being built to the old standards and WTMJ being built to the revised standards that took effect after the NRSC rules were incorporated, 3) WTMJ operates daytime with the IBOC-AM HD system, 4) I have plots of the predicted null-angle-rotation of the pattern at +/- 10Khz which were requested by myself to determine if the WTMJ array was broadband at the time of construction, and 5) I am familiar with the reception conditions possible from WMT in western Illinois prior to IBOC operations commencing at WTMJ. In addition, WTMJ has the honor of being co-first stations, along with WSUN in Florida, to utilize directional patterns to reduce co-channel interference at night: They started it all back in the 1920's! Studying the 0.5mV/m contours, it is clear that the 0.5's do cross, but no where near the level of mutual interference that would be created to a pair of stations that had both been constructed prior to the rules changes, thus having a 2 / 25mV/m contour requirement. The amount of crossover is about 6dB for the case of these two stations; which is about 16dB less interference than could be associated with 2 grandfathered stations, the level at which most stations operating at today are.

The results: Listening tests were done with a pair of receivers. The first is an older (1994) GM/Delco model that complied with the NRSC AMax certification requirements it had a 6.5kHz equalized audio bandwidth. The second is a new (2003) Delphi radio which has a significantly narrower filter (about 2.3kHz / -3dB and -14dB / 5kHz). While both receivers could pick up WMT perfectly well on 600kHz when WTMJ was operating (about 5 years ago) with AM stereo and while running AM monophonic operating until recently without any interference from WTMJ at the .25mV/m field contour, WMT is unreadable in the wider, 1994 radio and discernable, but not intelligible on the newer 2003 test receiver. The difference between the two radios is that one does not radically reduce about ½ of the IBOC carriers interfering with the WMT allocation (+5 - +10kHz from WMT carrier), the newer one does reduce these carriers by a factor of about 21dB (averaged over the span from +5kHz 10kHz above the WMT carrier). This simple measurement indicates that the PSD measurements utilized to show interference compatibility of the IBOC system are flawed. Furthermore, as one drives to the protected 0.5mV contour, a rural location near Dixon, IL, WMT is still not listenable on either radio, although the audio is discernable on the narrower 2003 model radio. Bear in mind that the NRSC occupied bandwidth limits and RF emissions mask which was designed to offer at least a 26dB protection ratio at that point, with a goal of 40dB; a value obtained from listener studies published in the B. Angell report. This report, sanctioned by the NRSC AM improvement committee found that consumers needed at a 26 to 30dB SNR for music programming and as much as a 40dB SNR for talk programming, which is much of what AM is today. These listening tests suggest that the 13.8dB reduction presented earlier in this filing is not adequate for talk programming. In fact, substantially more than the 13.8dB suggested is probably required. The rest of the required reduction of an additional 10 15dB is based on the psychoacoustic effects of short burst of interference, such as those encountered by fleeting instances of clipping / distortion / IPM / other products associated with AM analog transmissions and the steady-state carriers associated with IBOC.

Part of the reason that the interference is higher than what I predicted in the WTMJ / WMT case is that the WTMJ antenna pattern is defined at 620kHz. While the bandwidth is substantial, there is rotation of the protected contours as one gets beyond +/-10kHz from carrier. Since intentional energy broadcast at these frequencies does radiate towards protected stations, and since the stations are entitled to protection from this energy as if it were co-channel, the radiated power needs to be further reduced to account for the reduction of protection due to null-steering with frequency. Figures 1, 2, 3, and 4 show the predicted array pattern, as calculated by the array / network designers, for +/- 10kHz, day and night patterns. Since these are predicted patterns, based on computer simulations when the array was designed, it is also expected that the pattern may actually be significantly worse than these plots would indicate. It is certainly so at +/- 15Khz, for which simulation data was not generated and at frequencies which will affect second adjacent broadcast faciolities.

It is also interesting to note that WTMJ-AM suddenly ceased IBOC transmissions in mid-April; just after the NAB convention. Prior to that time, there were numerous discussions of the interference presented to other stations, as well as the increased noise on their own signal, especially outside of the main lobe of the pattern of the directional array. Within the last week of the filing of these Comments, WBBM (780kHz – Chicago) has started IBOC transmissions. They are sending only the primary sidebands; I assume this is to avoid some of the self-interference problems associated with the secondary sidebands; especially in regions of re-radiation as well as the reduced audio quality realized to analog listeners when the 5kHz audio restriction is utilized (the audio frequency response is “loosened’ to 8kHz when the secondary sidebands are not transmitted). It is interesting to note that noise is still heard under the WBBM audio; especially during power line re-radiation areas and the 8Khz audio response gives the station a “strident” / “honky” sound on many receivers. It is assumed that some of this audio characteristic could be improved with adjustment of the processor; however, the high audio quality associated with an NRSC-1 / 2 10kHz limitation would never be met.

The interference from WBBM is apparent to a station located in Northwestern Indiana on 750kHz and which anticipates a Chicago audience. This occurs as a third adjacent problem is a function of the receiver itself. Unfortunately, it is the home-based radios that seem to be most susceptible to the interference increase. Stations on the first and second adjacent channels suffer the brunt of the interference increase from IBOC transmissions on WBBM. Specifically, 800kHz is severely effected as is 760kHz. It is particularly interesting to try to listen to WJR-AM in Detroit (760kHz – Class A / Clear Channel) near sundown. As soon as WBBM suspends IBOC transmissions at sunset, a substantially noise-free WJR is available for listening. While I have not traveled into Michigan to determine the interference contour, WJR must be suffering from substantial reduction of coverage area.

It is important to once again note that a broadcast station is licensed to operate in the public interest. An AM station must serve the 0.5mV contour and should not be allowed to waive coverage rights to this contour. If they are willing to ignore this portion of their coverage area, the argument could be made that they should reduce their power, thus their interference to others, such that they cover the audience they are concerned with. With this reasoning, stations should not be given the option to accept interference to

The Smallest Stations Will Suffer the Most

As a stock holder in a small AM station in Wisconsin (WRPQ – 740kHz), I was also interested in the effect IBOC will have on the coverage area of my station. WRPQ was constructed in the mid-1960's and was built to the limits of the older second-adjacent channel requirements: The 2mV/m and 25mV/m can be tangent to each other. One of my primary second adjacent channel stations is WGN in Chicago, about 150 miles distant. With our current analog AM stereo operation, it is possible to listen to WGN in the City of Baraboo. Likewise, WRPQ enjoys interference-free coverage to our 0.5mV/m contour, and the signal is actually listenable beyond the .25mV/m contour. Figure 5 indicates the 0.5mV/m contour for WRPQ along with the 26dB protection point (equivalent to 0.025mV/m co-channel) of the 200 watts allowed as total power that WGN can transmit in the spectrum from 730 – 740kHz. It is clear that adequate protection does exist. When the power is increased to 2kW for WGN's emissions from 730 – 740kHz (the location in which the primary sidebands of a WGN IBOC signal will occupy), it is clear that the resulting interference will be extremely damaging. In Figure 6, it is shown that the equivalent 0.5mV/m contours actually overlap by several miles – this is the point at which a zero dB protection ratio exists and it is within the 0.5mV/m contour of WRPQ! Furthermore, Figure 7 indicates the point at which the .025mV/m equivalent contour for WGN occurs – it is beyond the 0.5mV/m contour on the north side of the WRPQ facility – it completely encompasses the WRPQ coverage pattern! In reality, there will be perfectly good city grade coverage for WRPQ since it's signal strength will continue to increase as one approaches the transmission site, thus a 26+dB protection contour does exist. But it also says that a second contour of interference-limited coverage for WRPQ, due to a potential IBOC broadcast from WGN exists to the north of the WRPQ facility – an unthinkable situation. Note that WGN is not currently broadcasting IBOC; the interference contours have been predicted using standard FCC methods, assuming a ground conductivity of 8mmho (M3 values). The FCC rules do not suggest that unintentional interference of this level is tolerable. Intentional interference of this level is unfathomable. But it will be the norm if IBOC-AM is allowed to continue to deploy in its current form. Is this a worst case…..the answer is clearly NO. WRPQ exists without any short-space / grandfathered terms; there are many radio stations that were built with greater levels of overlap due to the rules that allowed a reduction of protection for a first service station to a market. I have not explored the allocations problems further, but it is clear that interference will be a significant problem for the thousands of stations that operate at power levels of 1kW and below. Some may not care about coverage to their protected 0.5mV/m contour, but I certainly do, especially since I serve a primarily rural market area.

<u>Problem Defined; What Can be Done?</u>

Now that IBOC broadcasting has commenced in the AM band, what can be done to correct the problem. One solution, to be blunt, is to simply shut it off until compliance with out of band power limits can be insured. Various steps could then be taken to correct the interference problems associated with IBOC-AM.

First, the on-air stations have shown that interference has increased as a result of IBOC. While some may push it aside stating that it only occurs where "people don't listen" an the additional interference is "worth the price to bring in digital broadcasting services on AM", there are a lot of smaller stations that are going to be harmed by the new levels of interference that IBOC causes. It is time to re-consider the levels of interference generated, the methods by which they are measured, and the basis to which stations have rights against undesired / unintentional interference (from the protected stations standpoint).

Second, the IBOC carriers are not, and should not be considered <u>undesired / unintentional</u> artifacts of modulation; they are <u>intentional transmissions</u> into the protected spectrum / channel allocation of another licensed facility. Therefore, the stations receiving interference, out to their protected contours (at least the 0.5mV contour with 26dB protection / 0.1mV contour for Class A stations), are entitled to fully utilize their licensed spectrum without harmful interference from other sources, intentional or otherwise. The FCC rules have not changed with regard to these protection levels and a sub-part of 73.44, paragraph C indicates that even at these levels of protection, stations receiving harmful interference can request additional protections be made as well.[2]

Third, the NRSC methods of measuring occupied bandwidth and interference to adjacent and second adjacent stations are obsolete when it comes to digital modulation methods where the interference is continuous and white noise-like, thus delivering power across a portion of spectrum licensed to another operator. What is essentially a PSD measurement utilizing the current analog NRSC rules on an IBOC primary digital signal transmission is ineffective at measuring the total power delivered to the second adjacent channel. The FCC has methods at its disposal to measure or predict the total energy within a spectral allocation, in this case, the second adjacent channel. These measurements are commonplace today for systems such as the ATSC DTV standard as well as OFDM, spread spectrum and other transmission systems in use today. One cannot base the interference power of a system on a PSD measurement without first calculating the reduction on a per-carrier basis.

What can be done to “fix the system?” In a nutshell, there are only two real choices and a third option that should be considered:

First, if the existing system is used, the power of the primary digital sidebands must be reduced by at least 13.8dB over the current values. At this point, some stations will still encounter interference, but at least good engineering practices can be shown for the injected power levels utilized.

Second, the primary and secondary sideband locations could, and should be reversed. Although the noise levels of the IBOC-AM facility will be increased to their own monophonic, analog transmission, the published values for CHs1 and CHs2, the secondary OFDM carrier levels currently located from +/- 5 10kHz from the assigned carrier frequency, are -43 and -37dB respectively. If both terms are at least -39dB, the requirements of interference reduction set forth in this paper will be met. From the standpoint of noise to the analog envelope modulation term (almost all the current listeners), should the argument not be that the additional noise should be to your own licensed facility, not to a licensed facility on a second adjacent channel? Why should an IBOC broadcaster be allowed to push his interference from himself to another legally-licensed broadcaster?

Third, a re-allocation solution exists which would be relatively easy to implement. This shall be discussed separately, below.

The final question is, “What about nighttime limits?” The simple answer is that the same limits imposed by the day limits described above and spelled out in 73.44 should account for nighttime operation. The reason for the uproar at night is the simple fact that the daytime limits are not being met. As an alternative, one could calculate the allowable night limit contribution to their first and second adjacent channel stations and adjust the IBOC injection levels accordingly, but I think that the work involved, and the resultant calculated power limits would make this entirely unacceptable and unattractive. One thing is certain: If the injection levels are reduced to -39dBc or greater (preferably 5 10dB lower than that level), nighttime operation could commence with sound engineering justification on an interference basis. What the coverage area at these power levels would be is anyone's guess…… But just think of the 1kW station operator out there today. For daytime operation, he would have to limit his IBOC injection level to the -39dBc level corresponding to 8 watts! And that is for both sidebands…..

Alternative Spectrum for Use by AM Broadcasters to Implement Digital Transmissions

While I still believe the best engineering solution that would offer the highest quality of service to the public would be a new allocation for both AM and FM broadcasters to begin Digital-only transmissions based on a multiplexed, multiple-access OFDM solution. It was shown by the late Dick Kennedy at Delco Electronics that a TDMA-based solution could have resolved the coverage matching issues raised by some. Such a solution, similar to the Eureka-147 solution would have been ideal; however, this did not happen. Therefore, the "compromise" IBOC-FM solution should be the model for digital broadcasting.

We have a unique opportunity to gain access to 12 MHz of spectrum in which fully digital (skipping the hybrid stage) transmissions could take place; thus providing ample room to accommodate all current AM broadcasters. The spectrum proposed is just below the FM band at 76 – 88MHz. These are currently television channels 5 and 6. With the re-farming of the television bands as DTV is implemented, it would be possible to move these stations to other VHF-HB or UHF channels. The benefits far outweigh any potential short-term hardships to the television broadcasters:

1) The proposed allocation is already the FM entertainment band in other parts of the world including Japan; thus, nearly all receivers designed include this band – it is made available through regional programming of the radio microprocessor controller. In this way, identical standards could be used for digital broadcasting by all broadcasters and receivers can be optimized at lower cost.
2) Interference-free transmissions in the current AM band (530 – 1710kHz) can continue without loss of coverage / increased interference by ANY broadcaster.
3) Nighttime issues are immediately resolved; current coverage is maintained.
4) AM Broadcasters would have the option to utilize band-limited digital systems such as DRM and CAM-D as well as current analog transmission systems such as C-QUAM stereo and PowerSide compatible SSB.
5) AM receiver development based on DSP / Digital demodulation of the analog signals can continue; the resultant being further development of adaptive bandwidth receivers which do not increase the cost of a consumer radio set.

6) In regions where either channel is already available, implementation can begin immediately. In other regions, these allocations would become available as NTSC television transmissions cease over the next few years.

Conclusions

1) Stations should not be required to reduce audio bandwidth below the 10kHz NRSC-1 / 2 standards; if they are, the occupied bandwidth rules (73.44) should also be reduced to conform to the analog envelope – 10k0 vs. the current 20k0 emission designation.
2) PSD measurement techniques are not sufficient to calculate equivalent interference power to a second adjacent channel station unless a bandwidth / number of OFDM carriers correction factor is incorporated into the measurement technique,
3) Reduction of the primary sideband power to a level of -39dBc as measured on a spectrum analyzer will produce the same level of interference protection as that envisioned by the NRSC committee and as incorporated into the FCC rules, namely, 73.44.
4) A reversal of the primary and secondary digital sideband locations, as well a reversing their injection levels in the IBOC-AM system will reduce the second adjacent channel interference to legal radiated power limits which form the basis for the reasoning behind FCC rule 73.44 at the expense of increased interference to the analog signal of the IBOC station (not their adjacent and alternate neighboring stations),
5) The techniques described to measure the level of interference are commonplace in other licensed medium, will also correct the nighttime issue currently plaguing the IBOC-AM system, and will restore the ethical practice of creating interference / incompatibility to your own station rather than pushing it off on to another station, and
6) The definitions of unintentional vs. intentional emissions / radiation, which are commonplace in the FCC rules, must also be applied to the AM band to protect the property rights / coverage area of channels operating on the second adjacent channels of an IBOC-AM station.
7) If IBOC-FM is fully accepted and continues to be available to the consumer, an alternate band for re-allocation of AM broadcasters should

replace the 12MHz allocation of VHF-LB television channels 5 and 6 at 76 – 88MHz. AM broadcasters should be given an allocation sufficient to broadcast a fully digital IBOC-FM transmission, with coverage based on power / height allocations which reflect their current AM coverage areas.

[1] Sec. 73.44 AM transmission system emission limitations.

(a) The emissions of stations in the AM service shall be attenuated in accordance with the requirements specified in paragraph (b) of this section. Emissions shall be measured using a properly operated and suitable swept-frequency RF spectrum analyzer using a peak hold duration of 10 minutes, no video filtering, and a 300 Hz resolution bandwidth, except that a wider resolution bandwidth may be employed above 11.5 kHz to detect transient emissions. (emphasis added)

[2] Sec. 73.44 AM transmission system emission limitations. (c) Should harmful interference be caused to the reception of other Broadcast or non-broadcast stations by out of band emissions, the licensee may be directed to achieve a greater degree of attenuation than specified in paragraphs (a) and (b) of this section.

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Signed,

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July 18, 2005

Via Electronic Filing

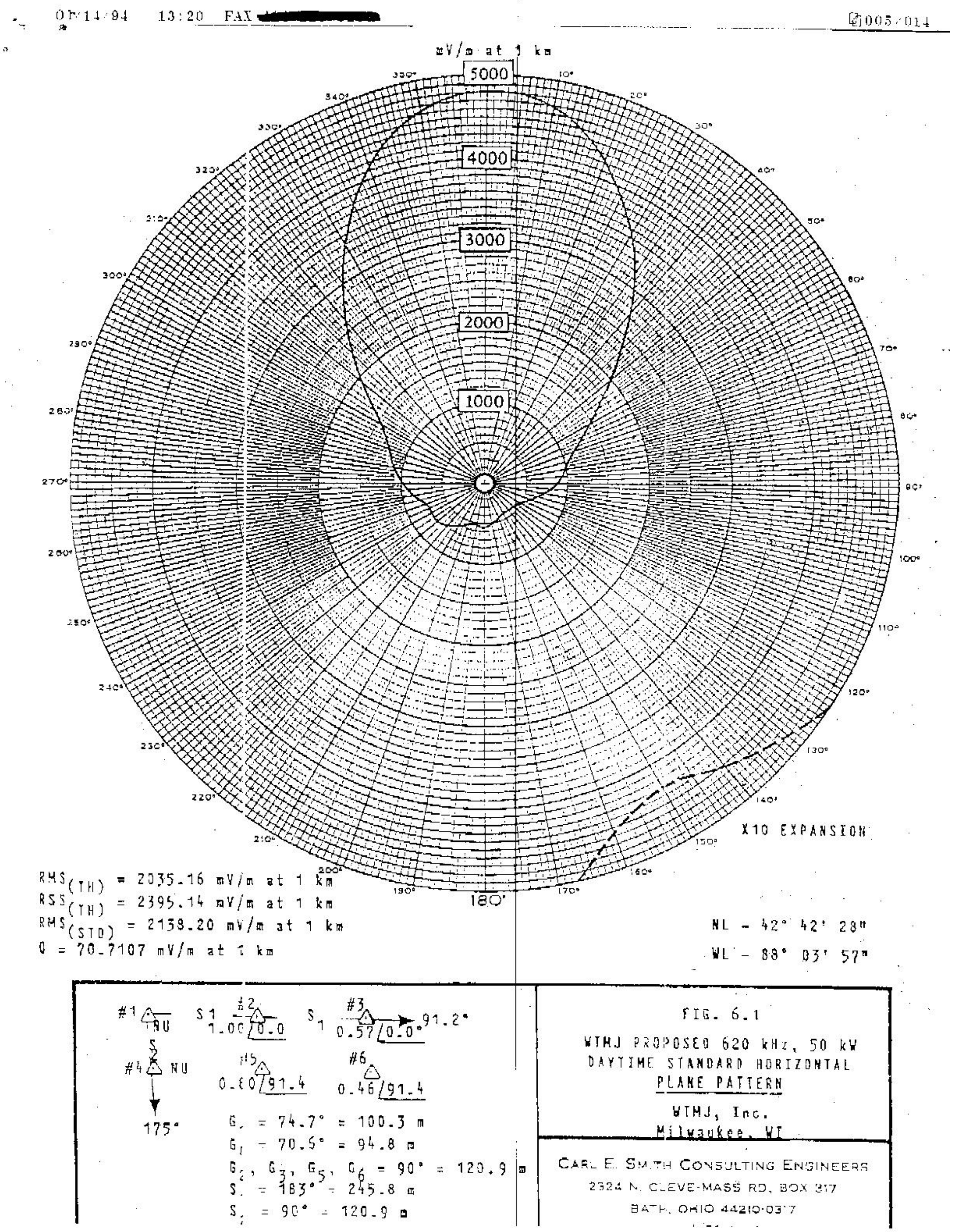

Figure 1 WTMJ Pattern On-Channel (620kHz) Daytime Operation 50kW

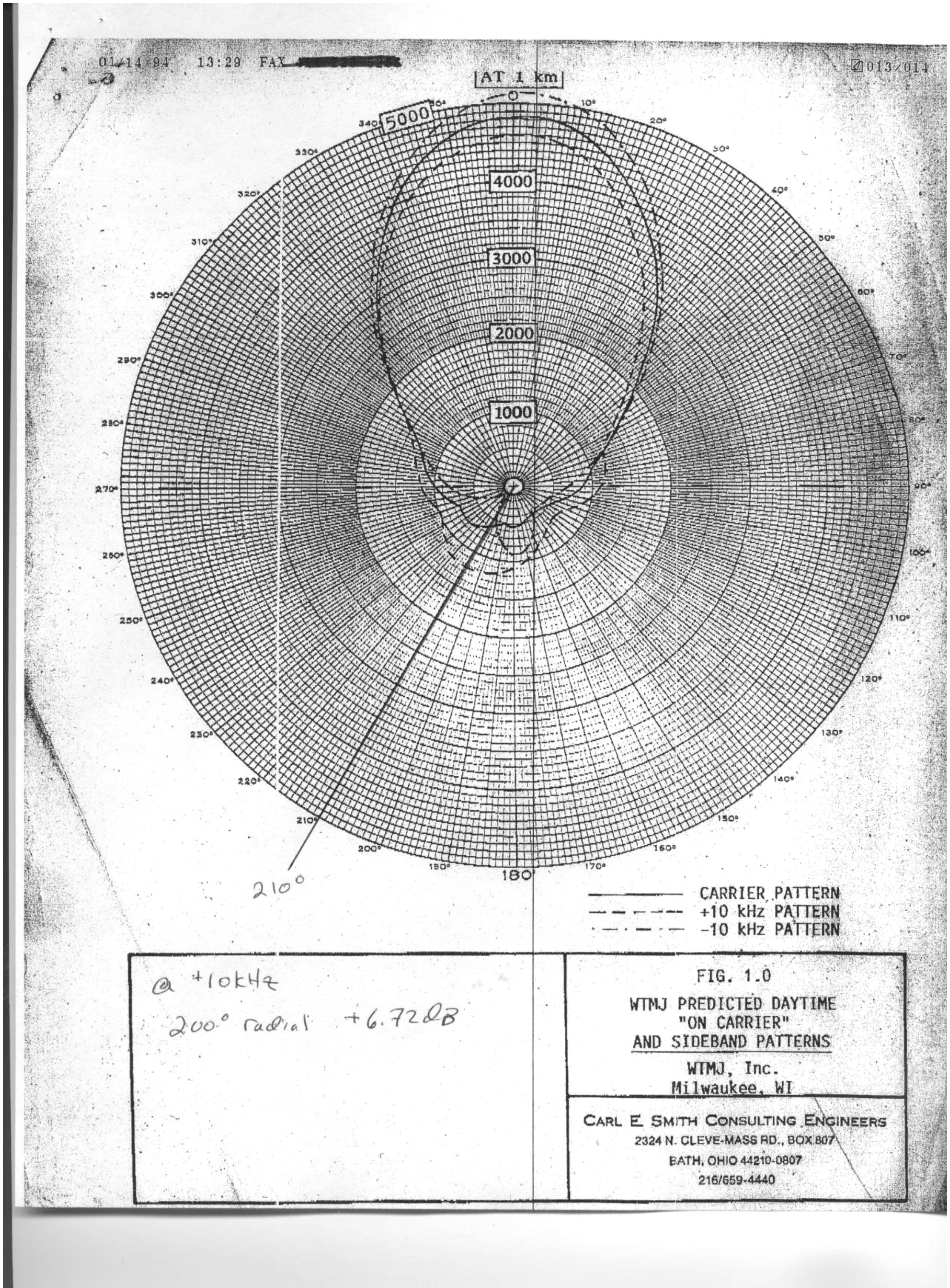

Figure 2 WTMJ Pattern at +10kHz (630kHz) Daytime Operation Highlighted

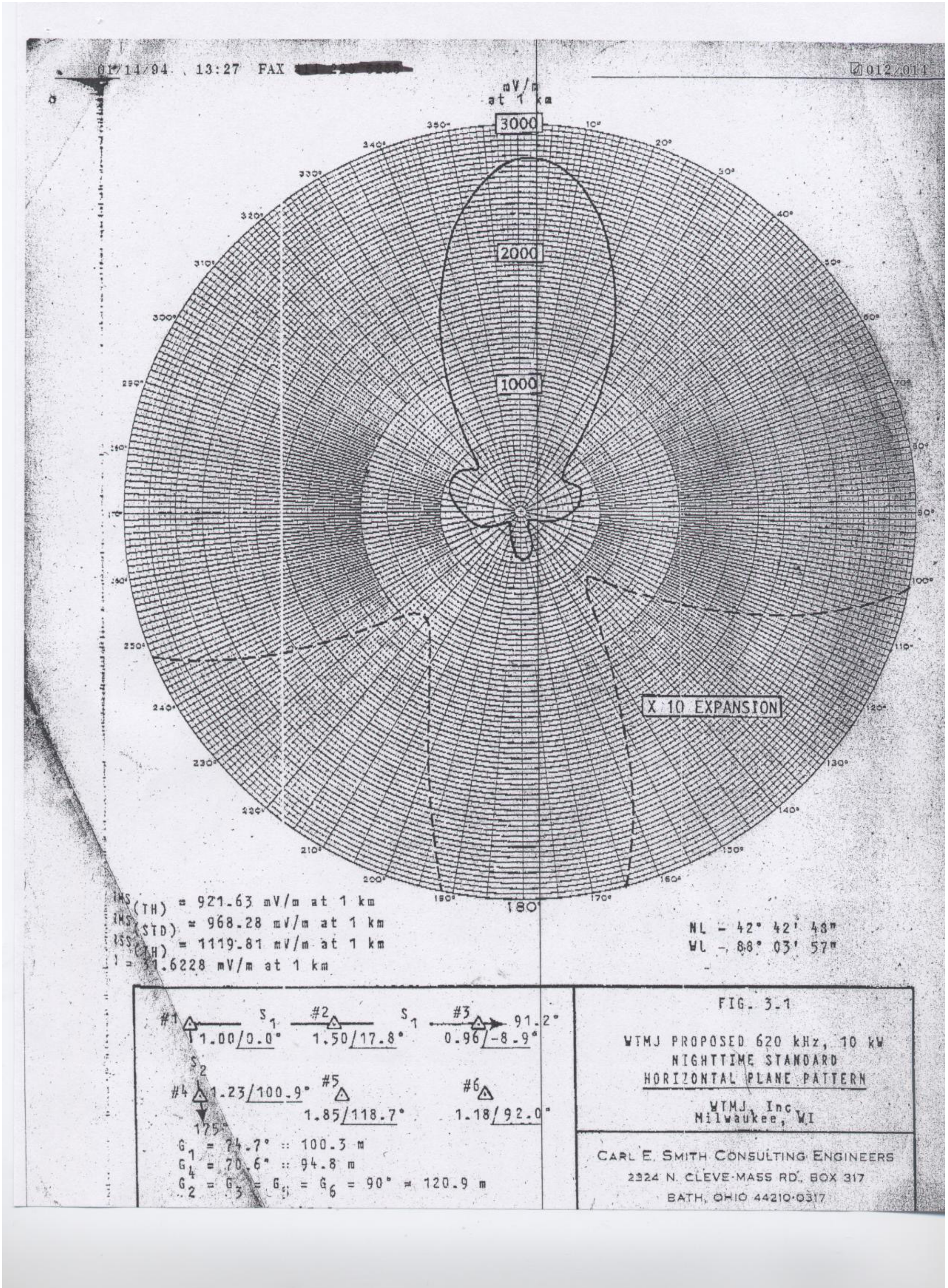

Figure 3 WTMJ On-Channel (620kHz) Nighttime Operation

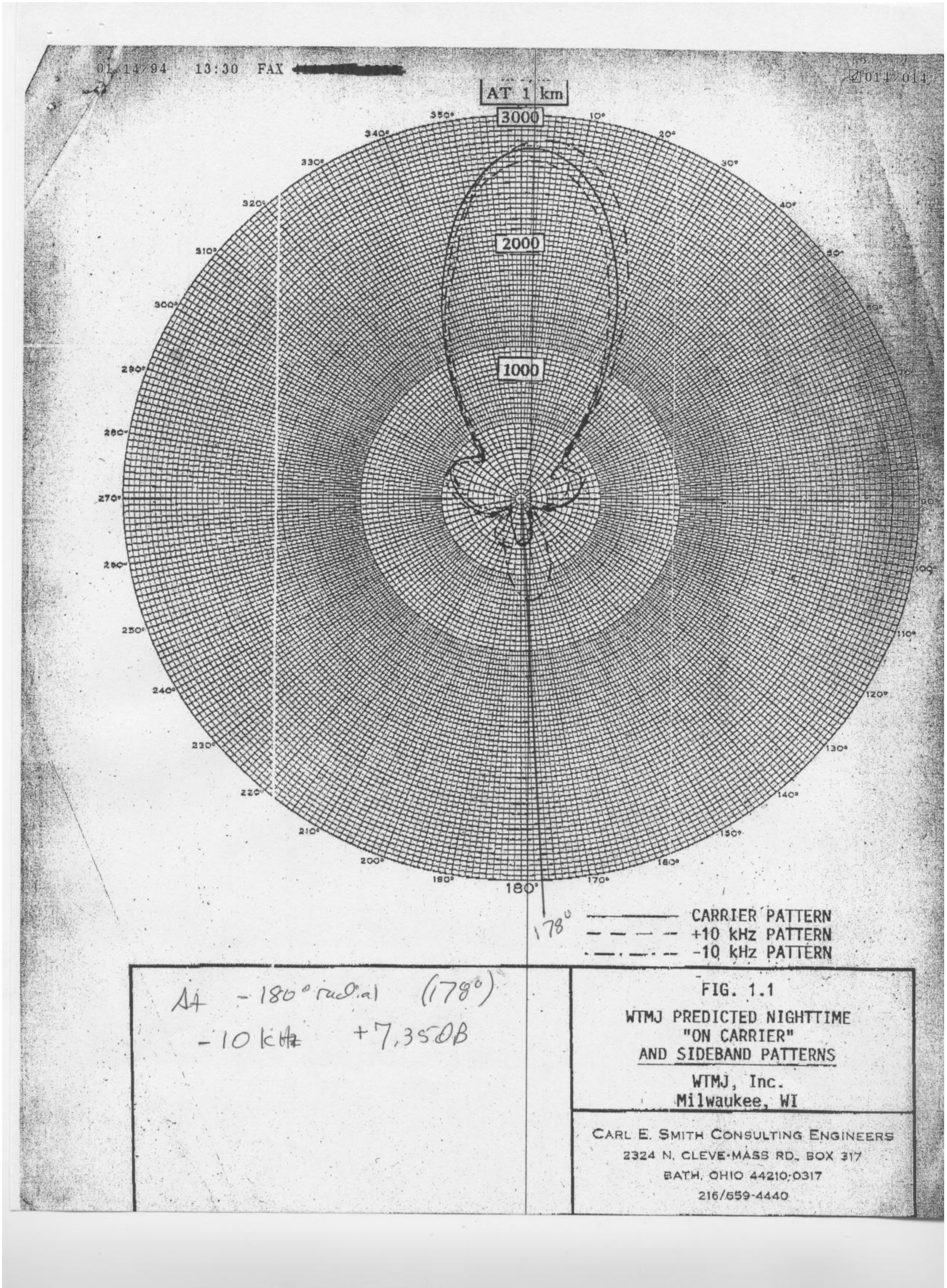

Figure 4 First Lower Adjacent Pattern (610kHz) Nighttime Operation Highlighted